Chapter Seventeen

Science in the Desert

The promise and prospects of nuclear energy were high and the problems were few.
We were the good guys.

–William Ginkel–

Hugo N. Eskildson replaced Allan Johnson as the IDO manager, but after a troubled term lasting only two years, he left the NRTS. The interlude had been uncomfortable for other IDO administrators and the business leaders of the town, who realized how important their mutual regard had become. The IDO wanted to preserve the support it enjoyed from the community, and the business leaders wanted to preserve an environment in which that support would continue. As Allan Johnson pointed out when he resigned, the NRTS had grown on his watch from 1,400 to 4,000 employees. The number of reactors had risen from seven to thirty. The NRTS was fulfilling its promise as a propellant for regional economic growth.[1]

The AEC elevated Eskildson's deputy, William Ginkel, as acting manager in September 1963, making it permanent in April 1964. Ginkel was the first of the managers not to share the military background of his predecessors. He had worked as a civilian at Oak Ridge from 1944 through 1950, first for contractor Tennessee Eastman and then for the AEC, involved with the chemical aspects of keeping track of uranium. His degrees at the University of Rochester included chemical engineering and business administration. With the opening of the NRTS, he saw an opportunity for promotion and a chance to join an emerging engineering outfit. After a successful IDO interview, he wondered how he might persuade his southern-born wife to love the West. Used to lush vegetation, she had her doubts about the desert. He sent her photographs of the lovely gardens around Idaho Falls' Tautphaus Park and the Latter Day Saints temple. Desert or no, Idaho offered them both—and others who had lived behind the security gates of a government town—the welcome prospect of living a more civilian life in a traditional American neighborhood. After a series of promotions, at first in work related to the Chem Plant, and a short hiatus at Knolls Atomic Power Laboratory in Schenectady, Ginkel reached the upper tier of IDO management.[2]

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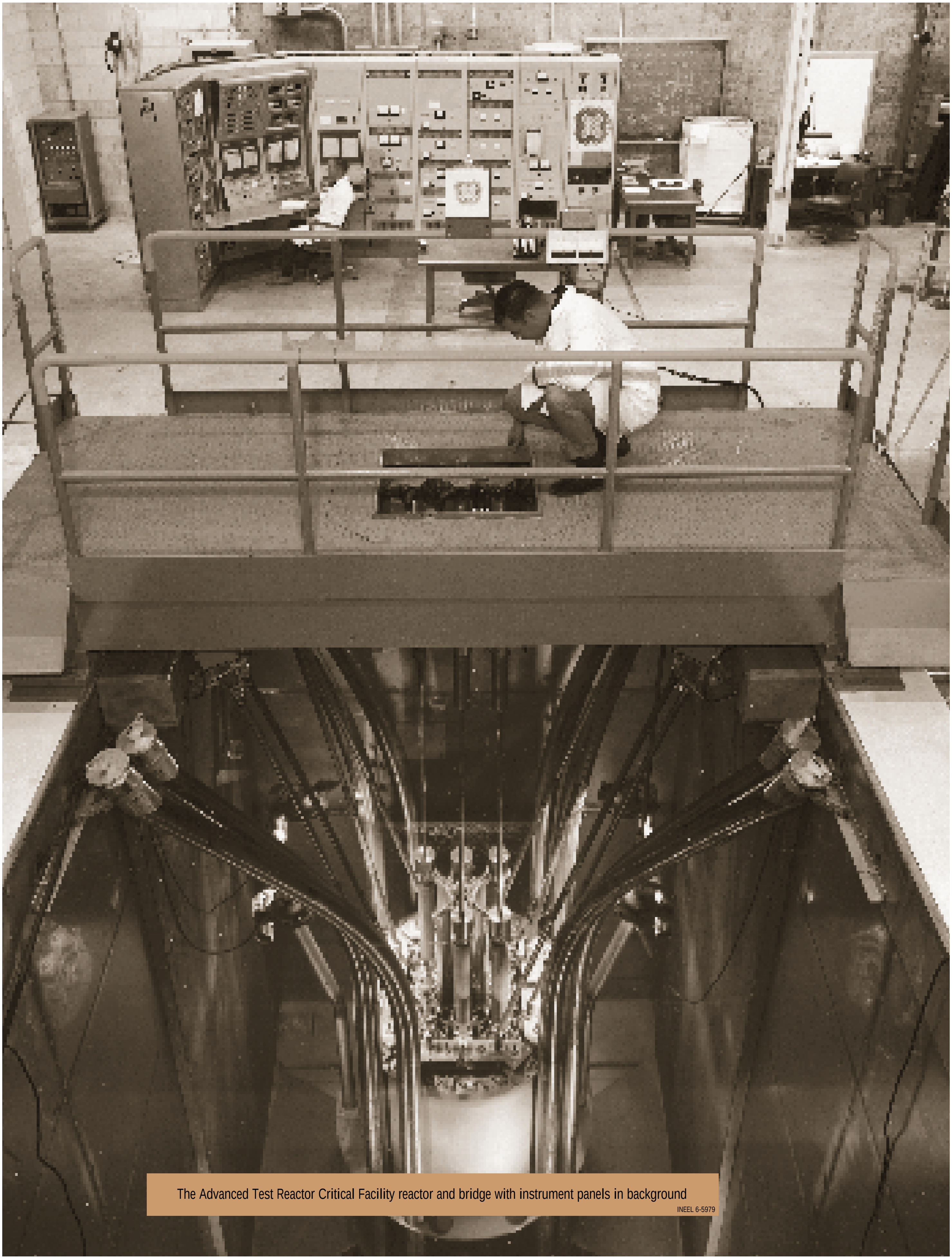
William Ginkel

Just as Ginkel moved into the manager's office, Dr. Richard Doan, aged sixty-five, retired from Phillips and the NRTS. Doan's unembroidered approach to work lasted through his final day on the job. "He spent his last day as if it were any other day—no round of goodbyes, he just worked until five o'clock and walked out," wrote one of his colleagues. Doan's retirement proved not to be very thorough. He had been a member of the AEC's Advisory Committee on Reactor Safeguards since its inception, and he continued to serve on this committee and as an advisor to the licensing staff for the AEC.[3]

Ginkel took office as reactor research was in full flourish everywhere at the Site. The success of the original four projects had led to second and third



The Advanced Test Reactor Critical Facility reactor and bridge with instrument panels in background

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Deslonde deBoisblanc

generations of the concepts they represented. In late 1963, construction crews were back in force, the annual payroll was high and growing, and new initiatives were evident everywhere. Even space-age projects had arrived at the NRTS. Nationally, nuclear power plants were about to move into the commercial market, and the demand for safety testing, NRTS-style, was growing. No matter where he looked around the desert, Ginkel could observe an impressive array of activity.

At the Test Reactor Area, the Navy was emerging as Phillips' major customer, and a third big testing reactor was on the way. The Navy's nuclear fuels were getting more complex, and the Navy wanted a test reactor with more precision than the ETR. It wanted to test full-scale fuel elements, which were getting larger and thicker, not just samples. Also, it wanted faster results, which meant having space in the reactor to run several tests at the same time and expose them to a very high flux of neutrons. ETR flux was too low and its test loops were too small.[4]

Besides that, the normal way of operating the MTR and ETR created problems. Typically, control rods moved up or down during operation to regulate the power level of the reactor. But if a test sample several inches long was in the reactor parallel to a control rod, the neutron exposure to the top and bottom halves of the sample would not be the same for the duration of the test. In the MTR the variation could amount to thirty percent; in the ETR, ten percent. The Navy wanted to reduce the percentage even more. Its planned experiments required perfect symmetry—or as close to perfect as possible—along the entire length of a test sample.

In the late 1950s, the AEC and the Navy invited a number of companies to make proposals for an advanced test reactor that would serve not only the Navy but the AEC's other test needs for many years to come. Despite study periods of up to three years, none of several responses met the Navy's demanding requirements within a reasonable cost or time. It appeared that the aluminum-clad/enriched-uranium reactor concept might have reached its limit of performance.[5]

The Navy asked Phillips to take two months to review previous proposals and come up, if possible, with a conceptual design. This challenge handed NRTS people a chance to prove they could still produce brilliant ideas. One of them, Deslonde deBoisblanc, a scientist with no doctorate in physics but who nonetheless had a feel for the way neutrons behave, created an elegant design for the reactor core in 1959. The design, named Advanced Test Reactor (ATR), first of all solved the symmetry problem. DeBoisblanc described the ATR's new way of controlling the power level.

I tried to avoid a common problem encountered in most other test reactors, where the control elements move up or down. In the ATR, the larger range of control is accomplished by rotating sixteen beryllium cylinders with hafnium shells that cover 120° of the outer surface. (Hafnium is a strong neutron absorber.) The cylinders are situated around the core. When rotated singly or in groups, the hafnium moves closer or farther from the core, thereby controlling reactivity without disturbing the vertical power profile.

The design also included small neutron-absorbing control rods. Unlike control rods in earlier reactors, these were not moved slowly up or down during reactor operations to effect their control, but either fully inserted or fully removed.

Another ground-breaking—and aesthetically satisfying—innovation in the ATR was how it wrapped the reactor's fuel around the samples in serpentine fashion, more than doubling the neutron flux (available in the ETR) to the sample. As deBoisblanc relates, it was during the long drive home from the Site that the "Aha!" moment occurred.

As was the custom, I was driving Byron Leonard, our consultant from Internuclear Company, to his hotel in

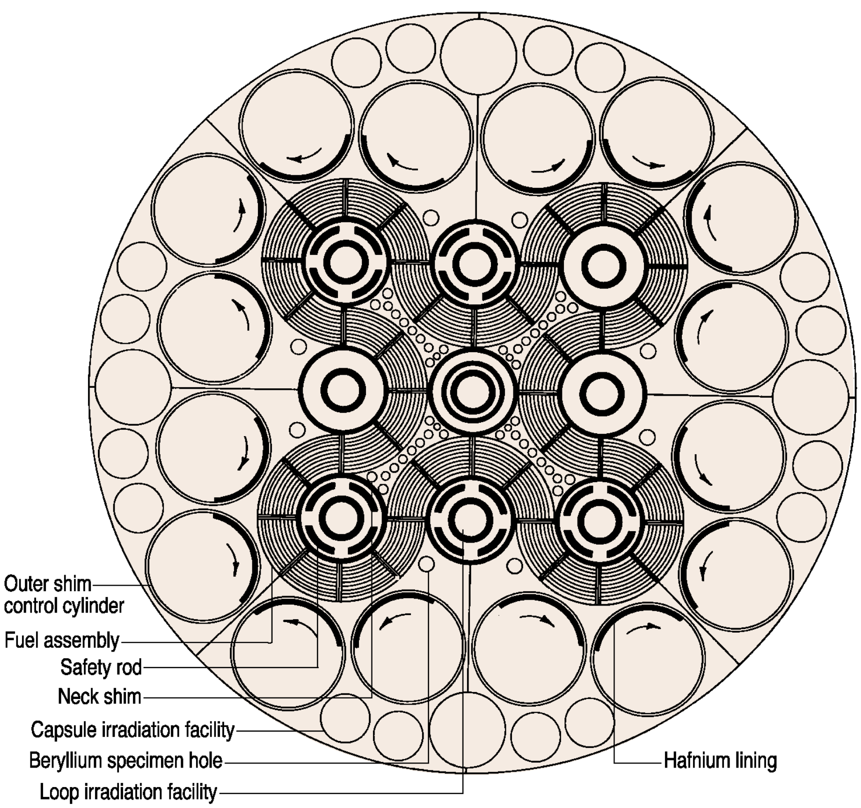
Idaho Falls. It was one of those lingering twilight evenings, still quite light. On that straight stretch of Highway 20 across the desert, with its sage brush and the frequent lava flow patches, there wasn't much to distract us.

I started to describe a novel way to look at the problem before us. I thought of breeder reactors, where the effort is to minimize the leakage of neutrons. I tried to think how we might make the neutrons leak in the direction of the sample, where we wanted to maximize the number of neutrons absorbed into the Navy's samples.

If we placed water between the ATR fuel and the sample, the fast neutrons would "leak" into the water and collide with hydrogen. This would slow them down and they would pile up to create a high slow-neutron flux. This is the so-called "flux trap," which I didn't invent.

I reached over across the front seat of the car and with my finger drew four circles for test loops, and then a snake-like fuel line partially around each loop. Immediately, I saw that we could place another loop at the very center because the four arcs that surrounded the center loop were almost as effective as a circle. It soon became obvious that by placing a beryllium reflector properly we could gain four more attractive loop locations.

The more we looked at that strange arrangement, the better it looked. Possible new locations for control elements became apparent. Byron was so excited he volunteered to lay out the configuration. He didn't get much sleep that night, but what he produced was remarkable. His plan view showed that the entire serpentine fuel arrangement could be produced with only one type of fuel element. The number of test loops grew from the original four to nine.[6]



This schematic drawing of the ATR core in cross section shows the arrangement of the nine test holes, the serpentine arrangement of the fuel assemblies, and the sixteen control cylinders. Note the hafnium lining on the cylinders. The hafnium-lined portion of the cylinder could be turned toward or away from the test hole, depending on the desired neutron flux.

The next several days brought the usual questions from devil's advocates. As always with a "rich" design, each negative, when resolved, revealed new capability. They sensed they had a winner. "We quickly loaded the ETR Critical Facility," said deBoisblanc, "to model the serpentine geometry. The stunning success of that program is another story in itself. The mockup was really the clincher."[7]

Arranging the core into multiple different flux-trap regions—in which the power level could be different in each simultaneously—was something that deBoisblanc did invent. Satisfied, the AEC and the Navy selected the ATR cloverleaf design. Native ingenuity at the NRTS had influenced the destiny of the lab one more time.[8]

Now the ATR was under construction just two hundred yards away from the MTR. At the groundbreaking in 1961, Governor Smylie had said that the $40 million project was the largest construction project in the history of Idaho, eclipsing the Mountain Home Air Base, which had cost over $30 million. With a capability of operating at 250 megawatts, the ATR would be the largest test reactor in the world. If projections held, it would begin operating in 1965.[9]

The MTR was still working, having surpassed 11,500 experiments. At the Second Geneva Conference on the Peaceful Uses of Atomic Energy in 1958, Phillips announced that the MTR had run on plutonium-239 fuel at a power level of thirty megawatts for several months, adding more luster to its reputation. As the first water-moderated reactor to do this, the reactor confirmed that plutonium could be a reliable and controllable fuel for power reactors. It was another first-in-the-world for the MTR.[10]

The ETR had been in service since 1957. The ETR's on-stream time was lower than the MTR's, mainly because the elaborate experiments took more time to set up. Competition for its service was heavy, especially with the space program considering nuclear applications.[11]

Other TRA facilities were equally busy. The early zero-power reactors had given way to more advanced models. The Gamma Facility had irradiated its first 100,000 samples and was approaching 200,000. The neutron physics program continued its exploration of neutron interactions with matter. The work most immediately served reactor designers, but also moved 20th century physics along in its progress toward understanding the atomic nucleus and ever smaller particles of matter.[12]

The NRTS had long ago burst the seams of its Naval Proving Ground inheritance at Central Facilities. The growing safety and materials testing programs needed support labs and office space. About $1 million worth of new space had been built in 1962, and more was on the way. The sponsors of MTR and ETR reactor experiments had to design the experiments, but they needed NRTS welders, pipe fitters, carpenters, mechanics, heavy equipment operators, and other specialists to build them. New and larger craft shops were popping up. Whenever a project or program vacated a building, someone else usually was waiting in the wings, seeking relief from crowded conditions elsewhere.[13]

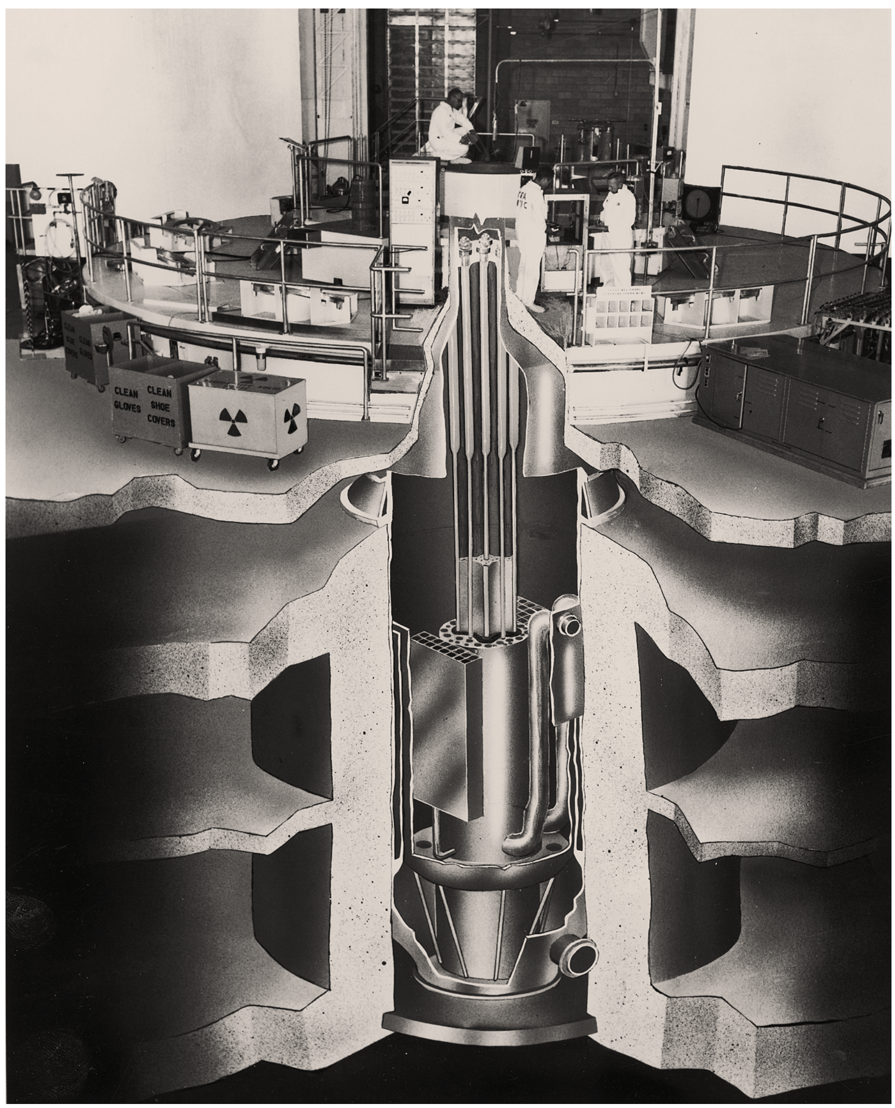


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Photo and schematic of ATR showing basements below operating floor.

One project that shut down in 1963 was the Organic Moderated Reactor Experiment (OMRE). The art of diphenyl isomers had advanced since Argonne's tar-making days, and this low-cost experiment ($1.8 million) had used something called Santowax-R as the coolant. The reactor operated for six years, proved itself with a succession of different cores, and served its purpose. The advantage of the waxy substance was that it liquefied at high temperatures but didn't corrode metal as water did. It could operate at low pressures, significantly reducing the risk of leaking.[14]

A California company, Atomics International (AI), had proposed and co-financed OMRE, the first such partnership between the AEC and the private sector at the NRTS. The HPs often recalled the California roots of the reactor because some of the process gauges were located outside the building. To examine them on a typical Idaho winter day required bundling up for the cold.[15]

The AEC decided to refine the OMRE concept and scale it up. The Experimental Organic Cooled Reactor (EOCR) went up next door, equipped with special testing loops and other advanced features. By December 1962, the facility was nearly complete. Then the AEC canceled the program, deciding the concept could not improve on the performance of breeder or water-cooled reactors. The EOCR was never loaded with fuel and never went critical. The building was recycled for storage and office space until the 1980s brought another recycle as a training center for the Site's security forces.[16]

Nevertheless, the concept had one chance elsewhere in the United States. The town of Piqua, Ohio, had responded to AEC's Power Demonstration Reactor Program and applied for a project. Its 11.4-megawatt reactor had been modeled after the OMRE and went critical in 1963. The town had to shut it down three years later when wax built up in the reactor core, making it hard to maintain and operate. Irradiation had changed some of the wax, which melted at higher temperatures.[17]


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Left. EOCR reactor facility in 1978. Below left. OMRE as it looked in 1978 prior to demolition. This was the first demolition as part of the official decontamination and decommissioning (D&D) program initiated by EG&G Idaho. Scientists researched D&D methods, tools, and procedures. Below right. OMRE area in 1980 after D&D.


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At Test Area North, things were happening at the old ANP facilities. A new series of reactors was going critical—and destructive tests taking place as scheduled. The National Aeronautics and Space Administration (NASA) was sending satellites into orbit and imagining future space exploration. It wanted to know if nuclear reactors might produce electricity for heat and experiments on space missions. Solar cells and chemical batteries were useful for short missions, but for longer ventures, these methods were either too low-power or too heavy. Reactors might optimize long life and light weight. Its development program was called Systems for Nuclear Auxiliary Power, SNAP.[18]

NASA planned to launch its first reactor into space in 1965 with an Atlas-Agena rocket. But first, it had to consider the consequences of potential accidents. A rocket might fail, for example, and the payload—reactor included—plunge into the ocean. NASA asked Phillips, which was conducting a safety program called Safety Test Engineering Program (STEP), to test a mock-up of the reactor, named SNAP-10A, and determine the radiation levels that might be released in such an accident. The NRTS had simulated submarines in the ocean, so it was no problem simulating a rocket crash in the ocean. The action on April 1, 1964, was at TAN. Richard Meservey, in charge of instrumentation, recalled:[19]

They took an old ANP double-wide rail car, put a huge tank on it and filled it with water. The tank had a plexiglass sleeve in the center to exclude water. The reactor was placed in the center of that plexiglass sleeve. When they were ready to run the test, they used explosives to drive the plexiglass sleeve away so water could rush in on the reactor. That simulated crashing into the ocean.


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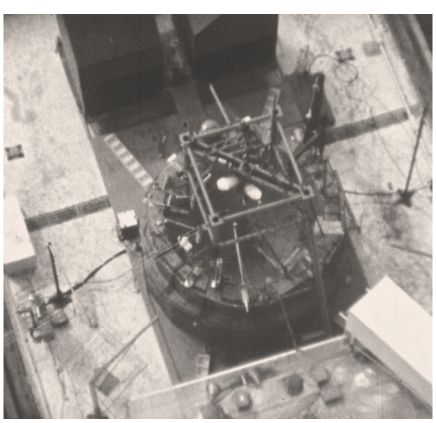
My job was to measure the temperature of the fireball if one should occur. I had a little hoghouse, a triangular structure set up at the ANP coupling station near the test. We had to worry about neutrons coming out and destroying the instruments, so we set up paraffin and cadmium shielding to thermalize the neutrons, and lead to stop the gamma radiation.

A fireball did develop and blew the reactor all over the area. We used a front surface mirror so that the direct radiation would not destroy the infrared temperature detectors. The detectors "looked" at the fireball via the mirror from behind the shielding. We knew we'd lose all the thermocouples in the fireball, so we used an optical pyrometer to measure the heat. It worked well.[20]

The program tested three SNAP reactors to destruction. HPs went on the road once more, tracing small puffs of radioactive iodine. Photographers captured the most informative views of the

Left. The ANP's shielded locomotive was recycled for use with SNAP transient experiments at TAN. Below. SNAPTRAN-3 destructive experiment, April 1, 1964.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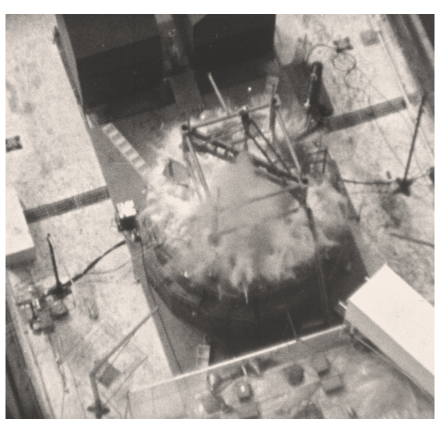
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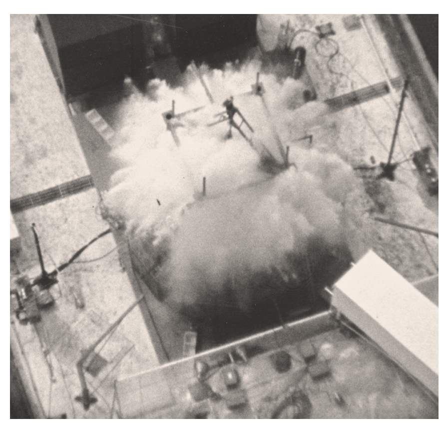
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explosions. Safety engineers imagined what else could go wrong—an accidental criticality on the way to the launch pad, for example. Then they engineered ways to prevent such an occurrence, such as shipping the fuel in small separate packages. The tests proved that the reactor would destroy itself, not continue to operate and build up a high inventory of radioactive fission products if it fell into the water.[21]

Reactor work, perhaps less photogenic than the destructive tests at TAN, was underway at every other corner of the Site. The Army was trying to perfect its small mobile reactor, the ML-1, hoping to conduct a continuous 500-hour run in the spring of 1964. At the NRF, the Navy was building the S5G natural circulation reactor prototype and enlarging the Expended Core Facility. The SPERT and TREAT investigations continued to unravel the mysteries of fuel behavior under abnormal conditions.

At Argonne-West, the first-generation breeder reactor was giving way to the second, the EBR-II. The venerable EBR-I ended its useful life in December 1963. It had run on four different fuel loadings since 1951. The first had bred new fuel at a scant ratio of 1.01, just barely replacing the fissioned fuel. The crew had mastered the handling of NaK coolant, learned from the 1955 meltdown what had caused instability in the fuel, and finally proved that plutonium fuel, although it had a low melting point and deformed under stress, could be managed in a breeder reactor as well as uranium. In fact, the breeding ratio improved to 1.27. And the locally made electromagnetic pump worked through all four core loadings, trouble-free.[22]

Now EBR-II was moving the breeder concept forward, scaling up twenty times larger than EBR-I. After its first criticality in November 1963, it advanced to the next milestones.

Argonne National Laboratory-West 5814

EBR-II turbine generator.

August 1964 saw the turbo-generating equipment produce electricity, at first in small amounts, then up to 62.5 megawatts. The reactor supplied all the power needs of Argonne-West with enough to spare for part of the demand elsewhere on the NRTS electrical grid.[23]

Argonne scientists were attempting a far more daring goal with EBR-II than merely producing electricity. The idea was to produce it efficiently. In addition to recycling its own fuel on the premises, Argonne also envisioned fuel that would "burn up," i.e., fission, a high percentage of its uranium fuel before it got so clogged up with fission products that it could no longer sustain a chain reaction. Unlike most other reactor fuels, EBR-II fuel was made of pure metal, not oxides. The fuel elements were pin-shaped, thirteen and a half inches long and of a smaller diameter than an ordinary pencil. The standard fuel was mostly uranium, enriched to 67 percent U-235, but alloyed with a few other metals. A standard fuel subassembly took 91 pins, which were arranged in a hexagonal pattern in the reactor. Aside from its excellent heat-transfer properties and superior breeding qualities, the metal fuel made it feasible to melt, refine, and fabricate new fuel elements just down the hall—literally.[24]

In September 1964, the EBR-II reactor operators removed spent fuel pins from the reactor—now containing fission products and uranium. About one percent of the fuel had burned up. After letting it cool for two weeks, they sent it through the FCF, the special argon-atmosphere recycling facility attached to the reactor building. (Argon gas was used to prevent sodium fires that were possible in ordinary air.) At a series of work stations arranged around the large circular cell, technicians removed spacer wires and chopped the pins into convenient sizes. Safe behind shielding windows, they manipulated their tools and ran the small furnace, heating the metal to 1,400°C and refining it. Finally, they vacuum-cast new pins in Vycor glass molds. The fission product waste ended up in a crucible as a blob vaguely resembling a skull, which is what they were called. New fuel pins, however, were ready for a trial run in the reactor.[25]

The pins performed well, as expected. EBR-II proved the principle. It continued running with recycled fuel from 1964 to 1969. By 1969, Argonne would raise the burn-up rate to 1.8 percent. During those years, there had been no shipping costs. No transit risks. No wasting of good enriched uranium. No storing of spent fuel under water for months and months. No liquid wastes that might leak. Just blobs of hazardous waste to manage. For those who worried about terrorists stealing plutonium, the set-up offered little opportunity.[26]

Of all of the reactor research done thus far by the AEC, EBR-II and its fuel recycling operation was the closest thing to a perpetual energy machine that had been invented. The political outlook for Argonne's breeder research looked as promising as the scientific. When the AEC abandoned the organic-cooled concept in 1962, it elevated the breeder concept at the same time. The Federal Power Commission (FPC) estimated that American energy consumption would double by 1990. It figured that the nation's fossil fuel supplies would be depleted within two hundred years. The FPC believed nuclear energy could—and should—displace fossil fuels and supply as much as two-thirds of the country's electricity by the year 2000. Under this scenario, the AEC accelerated its work on breeder reactors. The success of EBR-II was only a beginning. The concept still had a long way to go before it could safely scale up to a size competitive with fossil fuel power plants.[27]

Thus, the AEC had authorized Argonne to design a third-generation testing breeder reactor in Idaho. The Fast-Reactor Test Facility (FARET) would

Right. Inside the FCF's argon atmosphere hot cell. Note manipulators at right. Below. The view in the working corridor outside the hot cell windows.

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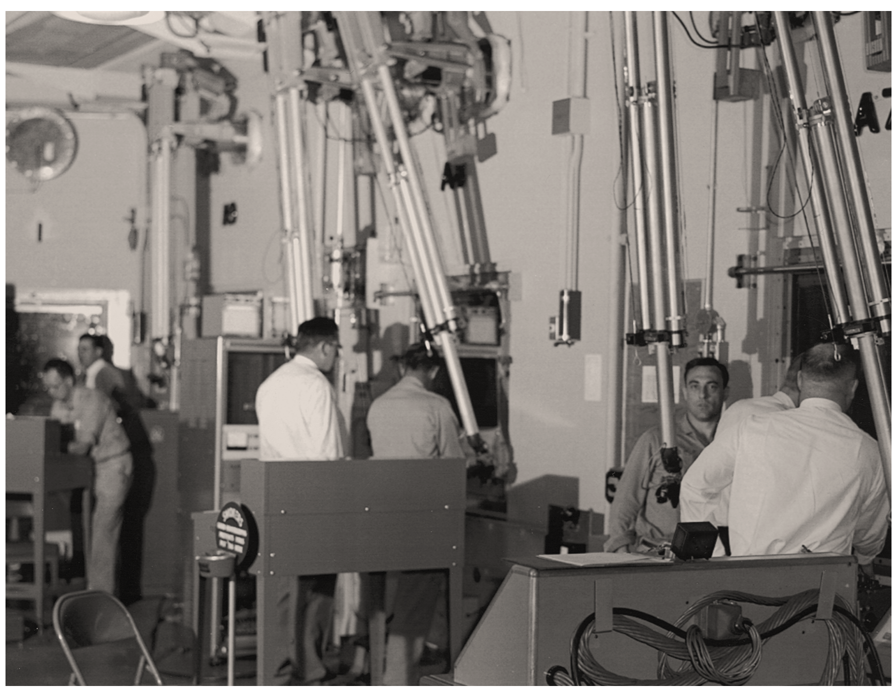

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take the concept well beyond EBR-II and the only other operating breeder reactor in the country, the Fermi plant in Detroit. It appeared, although it was not yet certain, that funding would be approved and that Argonne-West might see FARET under construction in 1965.[28]

Not all nuclear research at the NRTS was conducted at reactors. Environmental and health studies continued, and in 1963 the IDO went into the dairy farm business. Partly because of the growing frequency of destructive tests at the NRTS, each of which released small amounts of radioiodine-131, the IDO Health and Safety Division wanted to get a firm handle on the impact of these releases. If a large accidental release occurred—and one had occurred in England in 1957 because of a fire at Windscale's reprocessing plant—the IDO wanted to be ready with better emergency plans, not only for Site employees but also for downwind residents beyond the NRTS. To do that required a method of predicting how the iodine would behave. In addition, the information might improve the reactor siting criteria used at the NRTS.[29]

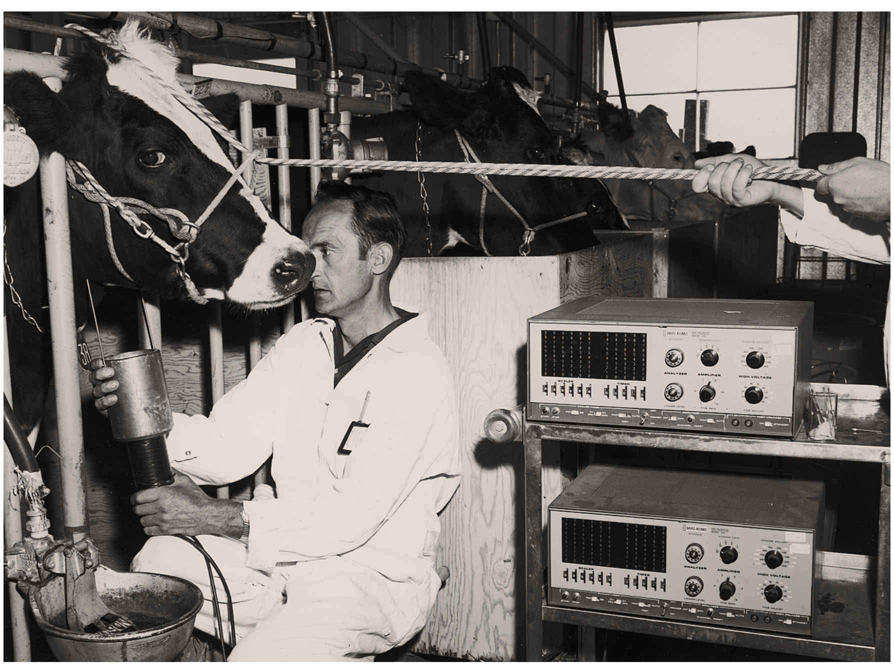
The pathway of I-131 from the air to grass to cows to milk and to humans had been generally understood since the 1950s. But local doses could be calculated only if local transfer patterns were known. Previous studies elsewhere had taken place mostly in laboratories. No one had tested how iodine actually behaved in a natural environment.[30]

The IDO knew there was nothing like a field study to answer questions and create predictive models. What amount of an I-131 release would deposit on the grass? After a cow ate the grass, how much radioiodine would go to its thyroid, through its body, or to its milk? After conducting a feasibility experiment on a field of crested wheatgrass near the southern edge of the Site, the IDO requested funds for a multi-year program.

In setting up the Experimental Dairy Farm, the scientists called upon local county agents and others to help them decide how much acreage would support how many cows, what kind of vegetation was typical on nearby ranches, and the details of cow management. Montana State University lent Hereford cows for the testing season. Because of this, John Horan observed later, "We had some of the best pedigreed animals in the world."[31]

The dairy farm project, managed by Clyde Hawley, used twenty-seven acres of flat ground about seven miles northeast of the Chem Plant—easy to get to and easy to cultivate. He set up a grid of detection instruments, dotting the pasture in regular lines and rows. Press releases went out, describing the purpose of the project and seeking bids from local farmers to care for the farm and six cows, irrigate the pasture, and keep milking records.[32]

The program was called CERT (Controlled Environmental Radioiodine Tests) and would involve many experiments over several years. Typically the manager ran tests at different times of the year. When ready for a given test, he would order iodine-131 generators from Oak Ridge and set them up at the upwind edge of the pasture and trigger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Inside the barn at the Experimental Dairy Farm.

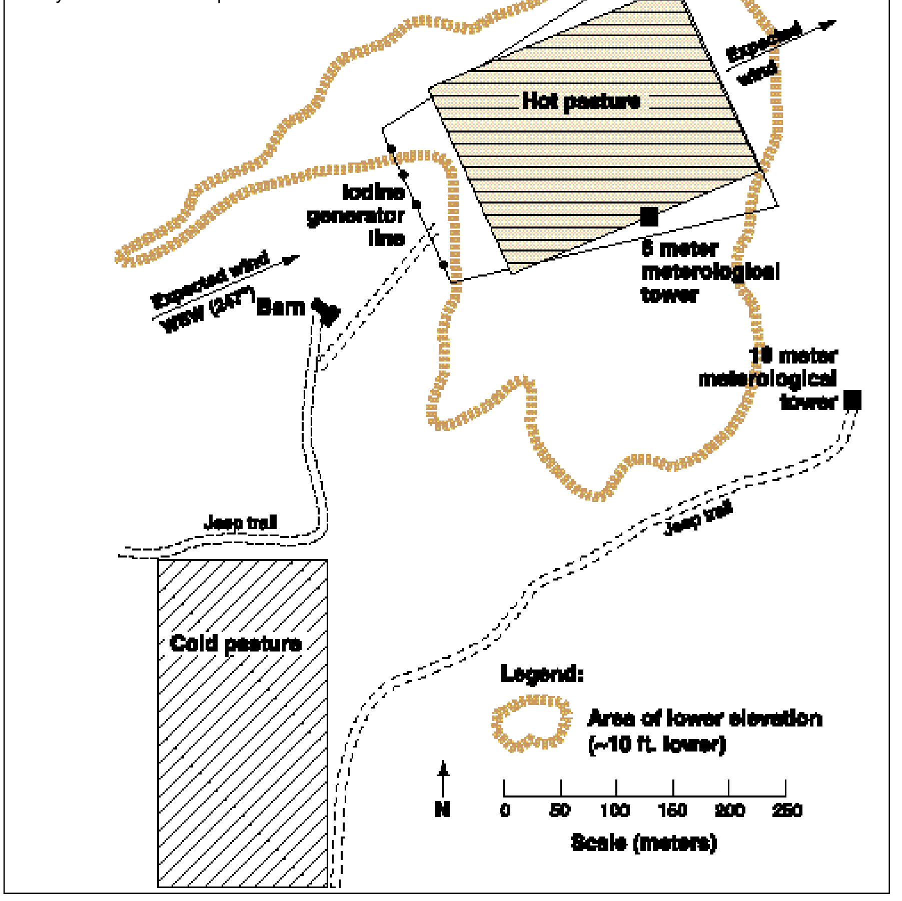
the release. Some iodine accumulated on the pasture grass. Cows ate the grass. Someone milked the cows. Technicians took samples of air, grass, and milk at suitably timed intervals, taking into account the eight-day half-life of the iodine. The IDO medical director, Dr. George Voelz, was a project advisor and recalled some of the early discussions.

We got to thinking about it. "Why don't we take it one step further? We'll get a few of us to volunteer to drink the milk, and we'll take the final step into the human." Clyde came to me to discuss it. The amounts were quite small, and I didn't see any problem. Ultimately he got six people to volunteer, all people working with him.

My concern was with the handling of the milk—bacteriological contamination. [The fact was,] we weren't set up as a milk supplier. He arranged to get a little home pasteurizer. In reality, we probably spent more time, at least as much time, talking about the bacteriology as we did the radiation.[33]

The proposal went to the IDO counsel. John Horan recalled discussing the implications of the Nuremberg Code. Nazi doctors had been convicted for crimes against humanity for human experimentation. In 1946 a code of conduct had been developed to guide human medical studies involving an element of risk. The key tenet was that "voluntary consent is essential." An approval and a sample consent form came from AEC Headquarters. It excluded Phillips or other contractor employees from participating because

Layout of first CERT experimental area.



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the AEC felt that the contracts provided insufficient liability protection to the government in case of a future claim.[34]

The experiments completed the last link in the iodine chain, imitating an accidental release. At first, the IDO volunteers simply sat in the field during the release and breathed. In later tests, after the cows had eaten contaminated grass, the people drank small quantities of milk. Subsequent counts, made possible because highly sensitive equipment was available to detect the small traces, identified how much iodine went to the thyroid and how much was excreted.[35]

The CERT program continued until 1977 in a series of twenty-nine experiments, although only a few early ones involved the human consumption of milk. Most of the tests aimed to discover how seasonal conditions or different grasses affected the behavior of the iodine. Taken as a whole, they demonstrated that iodine uptake was a function of vegetation type, climate, and the time of year. The measurements made it possible to predict from known releases how much iodine would make it through the consumption chain to human bodies.

The project expanded to include a laboratory in which to isolate variables that couldn't be controlled in the field and to help refine predictive models. The findings brought practical realism to emergency planning and reactor siting at the NRTS. But the impact of the work went much farther. CERT findings helped persuade the AEC to reduce the amount of radioiodine that a commercial light-water reactor would be allowed to discharge. The new standard—a maximum of five millirem annual total body exposure—was one thousandth of the standard in effect before the CERT experiments.[36]

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Over at the Chem Plant, the demand for recovered enriched U-235 had been slow for the last few years. After 1959, Hanford no longer sent highly enriched slugs to Idaho. From January 1960 through December 1963, the plant was on-line for a total of only twelve months. Runs were a month here, two months there. Likewise, the amounts of uranium were small, coming mostly from the MTR and ETR. The SL-1 fuel passed through the plant in 1962. After each run, the liquid waste went, as usual, to the big storage tanks.[37]

Then in 1963 things changed dramatically. The Waste Calcining Facility (WCF) went on line and revolutionized the management of radioactive liquid waste. Ever since the late 1940s, AEC chemists had been discussing what to do with the useless acidic by-products of uranium recovery. Pouring it in endless rows of tanks was obviously not a good idea. Acid corroded tanks—most likely within fifty years—and the long half-lives that made the waste such a hazard needed to be isolated from the environment for centuries, perhaps millennia. Chemists therefore talked of "ultimate" disposal and regarded tank storage as an "interim" step along the way.[38]

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Chemists at various AEC labs came up with ideas on how to remove water from the waste and reduce it to a solid. The AEC decided to try only one of the ideas, a fluidized-bed calcination process, and build it at the Chem Plant. The development program began in 1955, as scientists at Argonne National Laboratory tested the method in small-scale models. The process not only solidified the waste, but the product was granular, free-flowing, and easily handled by pneumatic transport techniques. Phillips engineers started designing the plant in 1956.[39]

To design the plant, the engineers had to know which radioactive elements volatilized and which remained solid. Argonne identified what became of the different chemicals in the waste when heated to various temperatures. By 1957 Phillips had enough data to design a demonstration plant. The next year the Fluor Corporation started building

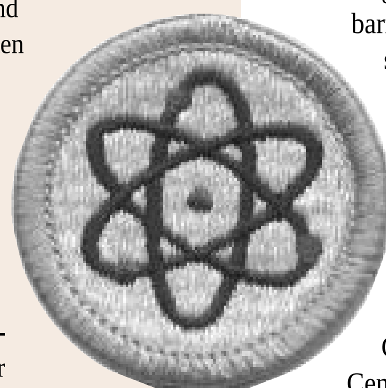
Above. Construction workers lower the calciner vessel into the calciner cell through a hatch. Left. Two of three surplus Navy gun barrels are shown in place during construction of the Waste Calcining Facility.

Atomic Energy Merit Badge

The 1960s expansion of nuclear power led the Boy Scouts of America to introduce the "Atomic Energy Merit Badge" to acquaint scouts with a nuclear energy career. This was the 104th merit badge in the series of Boy Scout badges, approved in 1963. Members of the American Nuclear Society expected to assist when scout troops asked for help.

The badge was a symbol of the lithium atom on a yellow background enclosed in a green circle.

To earn the badge, the scout had to discuss the meaning of terms such as alpha particle, curie, fallout, dosimeter, neutron activation, and Roentgen. He also had to select five scientists from a list of ten and explain their discoveries.



Required projects included making three-dimensional models of isotopes, explaining the difference between atomic weight and atomic number, and drawing the standard radiation hazard symbol.

A choice of optional projects might involve the scout in making and using a Geiger counter, building a model of a nuclear reactor, visiting a medical office using X-rays, making a cloud chamber, visiting an industrial plant where radioisotopes were being used, or comparing the progress of irradiated seeds next to non-irradiated seeds by growing both to maturity and noting any differences.

The AEC sent Idaho Senator Len Jordan two hundred booklets about the badge to distribute to his Boy Scout and Explorer Scout constituents.[43]

the facility just east of the Chem Plant's main process building and south of the storage tanks.[40]

The most common construction scene was the placing of concrete for thick shielding walls around the process cells—all of which were below grade. The engineers could not avoid locating three "hot" pipes directly beneath an access corridor where people would be working. At least one pipe would contain calcine—highly radioactive—on its way to a storage bin. So they made shielding tunnels out of Navy gun barrels, another successful scrounge courtesy of the old Proving Ground.[41]

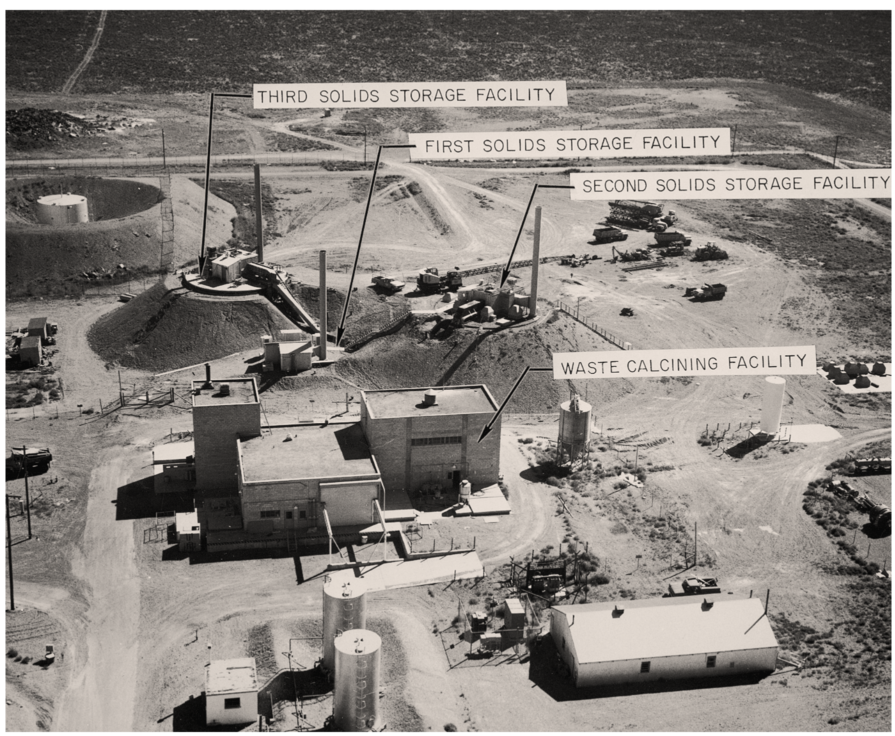
Learning to operate the fluidized bed required considerable experimentation, much of which was conducted at the Chemical Engineering Lab at Central Facilities. In 1961 Phillips began two years of "cold" operations, running simulated waste through the plant. The trials illuminated deficiencies in the equipment or the process, all of which the engineers had to adjust. At the same time, the safety teams imagined how malfunctions or human failures might put people in jeopardy. For example, what would happen if the plant had to shut down with calcine still sitting in the calciner vessel? Would decay heat cause the vessel to overheat? Answers to questions like this produced more engineered adjustments, more instrumentation, redundant equipment, and refinement of operating procedures.[42]

Now it was two days before Christmas in 1963. The years of preliminaries finally were coming to an end. Someone turned certain valves, and the hot waste from one of the Chem Plant tanks flowed into the building as a liquid and left as a solid. The magic was in the calciner—a cylindrical vessel four feet in diameter. It began by placing a bed of grainy material resembling sand (dolomite) at the bottom of the vessel. A NaK heat source placed within the bed of sand heated it to 400°C Then hot air flowed into the bed through fourteen holes at the bottom of the vessel, placing the grains in motion, or "fluidizing" them, like popcorn being air-popped in a theater lobby. Liquid waste, containing mostly aluminum nitrate, entered the vessel as a fine mist. In the hot environment, nature took its course. The water vaporized. Nitrate salts decomposed to nitrogen oxides and metal oxides. The solids adhered to the starter grains tumbling around in the vessel. As the process continued, the solids knocked against each other, causing small particles to flake off and form new starter grains for the liquid feed, which kept on coming.

As the solid—called alumina—accumulated, it left the calciner vessel through an overflow pipe. Pneumatic processes took over and moved it through a pipe (the Navy gun barrel) and on to storage bins east of the building. The water vapor and other off-gases left the vessel by another route, were treated, washed, and filtered and then exited the stack. One of the fission products in the waste, ruthenium-106, formed a volatile oxide that could not be allowed to go up the stack. The off-gas was routed into vessels containing silica gel, which absorbed the ruthenium-106.[44]

The calcine went to one of the bins in a "bin set," a group of four to seven tall, vertical steel bins nested together inside a thick reinforced concrete vault, in turn surrounded by earth and gravel shielding. The bins stood mostly above grade level, so the whole affair resembled a barren hill. Cooling air circulated past the bins, carrying off the heat of radioactive decay. Atop each hill were small shelters, called doghouses, for filters and the fans used to pull the air from within the bin set and send it up a small stack.[45]

INEEL 71-0848



INEEL 72-4571

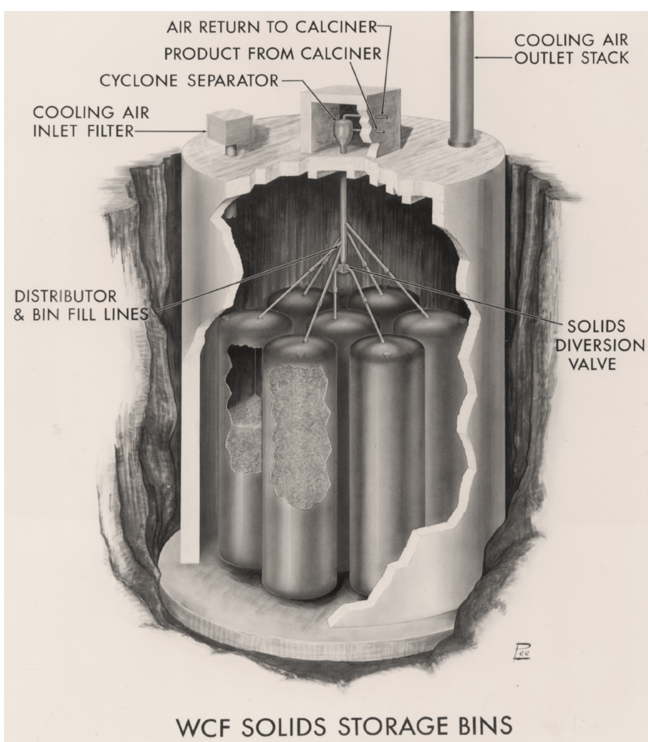
Above. One of seven "bins" is lowered into a bin set under construction. Bins will receive calcine and were built to last 500 years. Below. Waste Calcining Facility in 1972 showing location of the first three bin sets.

Operators referred to each run as a "campaign." The first one lasted until October 1964. Two 300,000-gallon tanks and part of a third were emptied before the campaign was forced to stop. In an excess of success, the campaign had filled up all the available calcine bins. Half a million gallons of liquid had been transformed into 7,500 bulk cubic feet of solid—a reduction in volume better than 9 to 1. The WCF had exceeded its design rate of 60 gallons an hour. None of the feed lines plugged up. Remote lubricating systems worked so well that no spares had to be put into service. The alumina traveled without incident from the calciner to the storage bins, despite several bends in the pipe. The gases leaving the stack included some strontium-90 and ruthenium-106, but the levels were below guideline limits. New bin sets went under construction, designed to last at least five hundred years and made so the calcine could be retrieved at any time in the future.[46]

Analysts who had predicted such matters as particle size and other properties of the alumina were gratified to find that performance matched prediction. The author of one report on the campaign credited these excellent results to the ten cold runs of the previous two years. All the rehearsing had made for a skillful and resourceful crew.[47]

Of all the innovations that streamed out of the NRTS, waste calcining turned out to be one of the most under-exploited outside of Idaho and the most profoundly valuable within Idaho. Neither Bill Ginkel nor anyone else could know it at the time, but the dry calcine tucked away in the bins would prove to be the safest, most environmentally reliable of all the methods then in use at any AEC facility for holding highly radioactive waste. The calcine could be retrieved from the bins if its constituents were ever desired for re-use. Or it could be transformed to a more inert ceramic or glass form for its "ultimate" disposal. At Hanford and Savannah River, where much larger volumes of waste accumulated, the practice was to put the waste, neutralized with sodium hydroxide in carbon steel tanks. This caused solids to settle into a radioactive sludge in the bottom of the tank—a sticky goo. It could not be re-dissolved in nitric acid without destroying the carbon-steel container as well. Nor could it be calcined. Several of the tanks leaked. Many Chem Plant scientists thought they had demonstrated a better mousetrap—a way to store very hazardous radioactive waste for centuries without threatening the environment—but the technology didn't transfer to other AEC facilities.[48]

The calciner, the breeder/fuel recycle experiments, the artful ATR, the reactor safety studies—all of the NRTS programs were at the leading edge of a hopeful new age of security and energy abundance. The NRTS was a unique place where opportunity was granted equally to all of the workers—meteorologists, health physicists, welders, chemists, electricians, instrument-makers, mechanics, laborers, physicists, engineers, managers, carpenters—to exercise daily their gifts of curiosity, imagination, and ingenuity. The founders had created in the desert a safe environment in which to experiment, to "prove the principle" and then to move engineering progress even farther. The laboratory was sanctioned by the nation and treasured by its neighbors. But the character of the national nuclear enterprise—and the Idaho neighborhood—was about to change. So would the NRTS.



INEEL 66-6863

Graphic representation of underground facility for storage of calcined wastes in granular form.

The Bus Ride

Hundreds of Site buses have traveled the roads of southeast Idaho carrying thousands of employees safely to and from work. Accidents were rare, but memories are abundant.

For 22 of the 34 years that I worked at the Site, I commuted a hundred miles a day to and from the Site on government buses, a total of over a half million miles. In the early days, the old Brill buses were rough riding, had straight-back seats, no air conditioning, and poor heaters. Their gasoline engines were very prone to breakdowns, especially in the middle of the desert on a hot summer afternoon or during an icy blizzard.

Joe W. Henscheid

I was one of those who played bridge in the back of the buses. We called it "bus bridge," because the rules were a little different. The bus ride only lasted an hour, so you had to bid to the ultimate.

In those days, around 1961, women couldn't wear slacks to work. We had to wear dresses and heels, no matter what the weather. During a terrible blizzard, an accident ahead stranded the bus caravan about halfway between Central and Idaho Falls. The bus driver kept the engine running to keep the bus warm, but it was a long time before another bus came along, and finally it ran out of gas. As the bus got colder, they put the women in the aisle seats, which were warmer than the ones by the window.

The men could get off the bus, turn their backs, and relieve themselves, but the women were handicapped by high heels and bare legs in trying to get out into the wind and the snow. Mostly, we never did, so there was a lot of discomfort. I think we finally got home around 2 a.m.

After this episode, Phillips relented some on the dress code. Whenever the temperature got below zero, we could wear slacks.

Myrna Perry

Above (top to bottom) White Bus, Brill Bus, Carpenter Bus, Gillig Bus, Crown Bus, Current Bus - MCI

We had a blizzard warning and the weather was getting worse and worse. At the time, I was at the Site. [The roads to Idaho Falls and Blackfoot closed.] Now the only way to go was to head for Mud Lake and the Interstate. So we convoyed and headed to town.

But a truck got stalled on the on-ramp to the Interstate, so the convoy had to head back to Central. On the way, the convoy picked up cars of people that had been coming from Salmon. They crawled into the line-up of buses and went back with us, feeling safer with a lot of company.

One bus stopped in Mud Lake and filled up with beer (although management didn't know this until weeks later). Gradually we made it to Central where Riley Foote, the manager of the cafeteria, caught up with us. I asked Riley to get out the steaks. He did, and we fed everyone who was there, even people who didn't belong to the Site. I washed dishes. People slept all over the place or played cards all night long.

For days after this, I got calls from people who normally worked at the Site and who hadn't got caught in the storm. They said how sorry they were that they missed the party.

Chuck Rice